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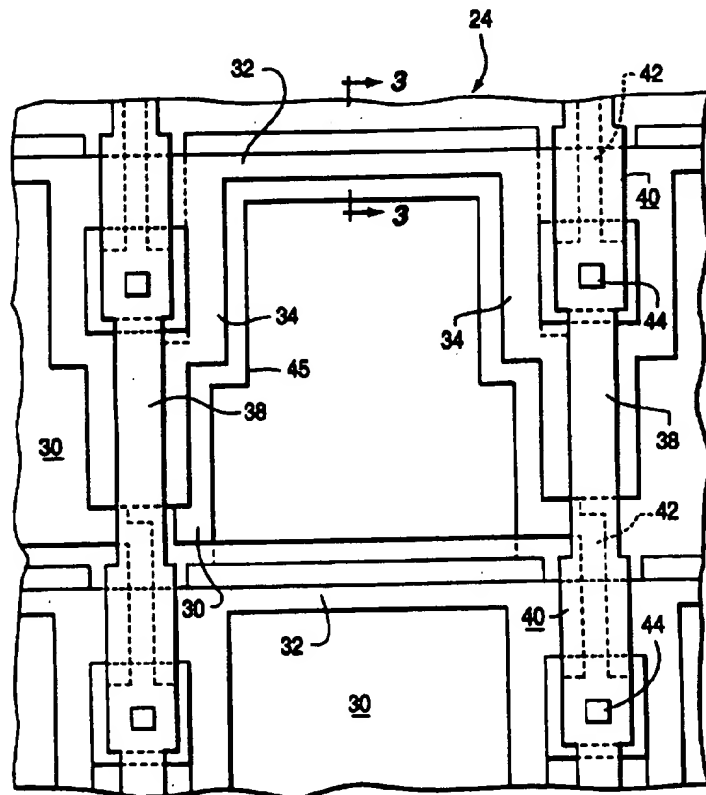
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(54) Title: LIQUID CRYSTAL DISPLAY WITH HIGH CAPACITANCE PIXEL

(57) Abstract

A liquid crystal display includes a base plate (26) having a plurality of pixels on a surface thereof with the pixels arranged in an array of spaced rows and columns. Each of the pixels includes a substantially rectangular region (30) of polycrystalline silicon. A separate select line (32) of polycrystalline silicon extends over and across the polycrystalline silicon regions of each row of pixels adjacent one side of the polycrystalline silicon region. The select lines have two extensions (34) extending over and along two opposite sides of each polycrystalline silicon region (30). A layer of a dielectric material (36) extends between the polycrystalline silicon regions and the select lines (32) and the extensions (34) of the select lines. Each of the select lines (32) and its extensions (34) forms a capacitor with the respective polycrystalline silicon region of each pixel. Data lines (38) extend along the rows of the pixels and are electrically connected (44) to each polycrystalline silicon region (30) in its respective column of pixels.



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## LIQUID CRYSTAL DISPLAY WITH HIGH CAPACITANCE PIXEL

The invention relates to a liquid crystal display (LCD), and, more particularly, to a LCD with a high capacitance pixel.

5 A LCD, in general, comprises a pair of spaced, parallel plates, generally of glass, each having an electrode of a conductive material on its surface facing the other plate, and a liquid crystal material between the electrodes. The electrode on one of the plates, generally the back plate, is divided into a plurality of individual, spaced areas which are arranged in a plurality of spaced  
10 parallel rows and columns. Each of the areas of the electrode forms a pixel of the display. Between each pair of adjacent columns of the pixel areas is a conductive line which forms a data line and which is electrically connected to each of the pixel areas in an adjacent column. Between each pair of adjacent rows of the pixel areas is a conductive line which forms a select line and which  
15 is electrically connected to each of the pixel areas in an adjacent row. Generally, each data line is electrically connected to each pixel area through a MOS transistor, and each select line is electrically connected to each pixel area through a capacitor.

In Fig. 1, there is shown a top plan view of one pixel of a prior art LCD  
20 10 which comprises a base plate 12 of an insulating material, such as glass, having on a surface thereof, an area 14 of a conductive material, such as polycrystalline silicon. The area 14 forms a pixel of the LCD 10. It should be understood that the LCD 10 includes a plurality of the pixel areas 14 arranged in an array of spaced rows and columns. The pixel area 14 is shown as being  
25 substantially in the form of a rectangle. Extending across the top portion of the pixel area 14 is a select line 16 of a conductive material, such as polycrystalline silicon. The select line 16 is insulated from the pixel area 14 by a layer of a dielectric material (not shown), such as silicon oxide, preferably silicon dioxide, or silicon nitride. Extending along one side of the pixel area 14 is  
30 a data line 18 of an electrically conductive material, such as a metal.

The data line 18 is electrically connected to the pixel area 14 by a MOS transistor 20. The MOS transistor 20 is formed by a strip 22 of polycrystalline silicon extending from the pixel area 14, across which extends the polycrystalline silicon select line 16' of the next adjacent pixel area 14'.  
35 The select line 16' is insulated from the strip 22 by a layer of insulating material (not shown), such as silicon oxide, preferably silicon dioxide. Thus the select line 16' serves as the gate of the MOS transistor 20. The data line 18 is electrically connected to the strip 22 on the side of the select line 16' away

from the pixel area 14. Thus, the portions of the strip 22 at opposite sides of the select line 16' serve as the source and drain of the MOS transistor 20.

5 The portion of the select line 16 which extends across the pixel area 14 and which is spaced from the pixel area 14 by the dielectric material forms a capacitor with the pixel area 14. The capacitor serves to stabilize the pixel voltage in the presence of leakage current and charge noise. To provide improved stabilization, it is desirable to have as large a capacitor as possible. One means for increasing the capacitance is to increase the size of the select line 16 so that it extends over a larger portion of the pixel area 14. However, 10 this would take up a larger portion of the pixel area 14 and thereby decrease the active area of the pixel area 14 and decrease the aperture size of the pixel. If the pixel area 14 is made larger to allow for increased capacitance without decreasing the active area, the overall size of the display would be increased. Therefore, it would be desirable to be able to increase the capacitance of the 15 capacitor between the select line and the pixel area without decreasing the active area and aperture size of the pixel and without increasing the overall size of the display.

The invention is a LCD which includes a base plate having a surface. At least one pixel is on the surface of the base plate and includes a region of a 20 conductive material having a plurality of sides. A conductive first line extends over and across the region adjacent one side thereof. The first line has at least one extension extending therefrom over and across another side of the region. A layer of a dielectric material is between the region and the first line and the extension to form a capacitor between the region and the first line and its 25 extension.

The invention is also a LCD which includes a base plate having a surface. A plurality of pixels are on the surface of the base plate and are arranged in an array of spaced rows and columns. Each of the pixels includes a region of a conductive material having a plurality of sides. A separate 30 conductive first line extends over and along one side of each of the conductive regions in each row of pixels. The first line has at least one conductive extension extending therethrough over and along another side of each of the conductive regions in its respective row of pixels. A layer of a dielectric material extends between the conductive regions and the first lines and extensions of the first lines. Each of the first lines and its extensions forms a 35 capacitor with each of the conductive regions in its respective row of pixels.

In The Drawing:

Fig. 1 is a top plan view of a pixel of a prior art LCD;

Fig. 2 is a top plan view of an array of one form of pixels of a LCD in accordance with the invention;

Fig. 3 is a sectional view taken along line 3-3 of Fig. 2;

Fig. 4 is a top plan view of an array of another form of pixels of a LCD of the invention;

Fig. 5 is a sectional view taken along line 5-5 of Fig. 4;

Fig. 6 is a top plan view of a portion of a modification of the array shown in Fig. 4; and

Fig. 7 is a sectional view taken along line 7-7 of Fig. 6.

10 In Fig. 2, there is shown a top plan view of a portion of a LCD 24 in accordance with the invention. The LCD 24 includes a base plate 26 of an insulating material, such as glass, having on a surface 28 thereof a plurality of substantially rectangular areas 30 of a layer of a conductive material, such as polycrystalline silicon. Each of the conductive areas 30 forms a pixel of the  
15 LCD 24, and will hereinafter be referred to as a pixel area. The pixel areas 30 are arranged in an array of spaced, parallel rows and columns. A separate select line 32 of a conductive material, such as polycrystalline silicon, extends across the top portion of each of the pixel areas 30 in each row of the pixel areas 30. The select line 32 has extensions 34 which extend over and along a  
20 side portion of each of the pixel areas 30. The extensions 34 of the select lines 32 are of uniform size and shape. As shown in Fig. 3, the select lines 32, including the extensions 34, are spaced from the pixel areas 30 by a layer 36 of a dielectric material, such as silicon oxide, preferably silicon dioxide. Thus, the select lines 32, including the extension 34, pixel areas 30 and dielectric layer 36  
25 form a capacitor with the select lines 32 and the pixel areas being the plates of the capacitor.

Data lines 38 extend along each column of the pixel areas 30 in the spaces between the columns of the pixel areas 30. The data lines 38 are strips of a conductive material, such as a metal. Each of the data lines 38 is  
30 connected to each of the pixel areas 30 in its adjacent column by a MOS transistor 40. Each MOS transistor 40 includes a strip 42 of polycrystalline silicon extending from each of the pixel areas 30. Each select line 32 extends across the strips 42 extending from the pixel areas 30 of the next adjacent row of pixel areas 30. The select lines 32 are insulated from the strips 42 by the dielectric layer 36 and form the gates of the MOS transistors 40. The data  
35 lines 38 have connections 44 which extend through openings in the dielectric layer 36 to electrically contact the strips 42 on the side of the select line 32 away from the pixel area 30 to which the strip 42 is connected. Thus, the data

lines 38 are electrically connected to the pixel areas 30 through the MOS transistors 40. The portions of the strips 42 on opposite sides of the select lines 32 form the source and drain of the MOS transistor 40.

5 A layer of a black matrix material, not shown, may be coated over the select lines 32 and the data lines 38 to hide them from being viewed through the LCD 24. The black matrix layer has openings therethrough over the pixel areas 30 as indicated by the lines 45 so that the active pixel areas are exposed to view.

10 In the LCD 24 of the invention, by having the extensions 34 of the select lines 32 extending over and along the sides of the pixel areas 30 as well as having the select lines 32 extending over and along the top portion of the pixel areas 30 substantially increases, about three times, the capacitance of the capacitor formed between the select lines 32 and the pixel areas 30. For example, for a display with a pixel size of 37 microns and having the select  
15 lines extending only across the top portion of the pixel areas as shown in the prior art display of Fig. 1, the capacitance area is about 66 microns square. However, for a display having a pixel area of the same size and with the select lines extending over along the sides of the pixel areas as well as across the top portion of the pixel areas as in the display of the invention shown in Fig. 2, the  
20 capacitance area is 201 microns square. However, even though the capacitance is substantially increased, the aperture of the pixel is not changed substantially. The aperture of the pixel shown in the prior art display of Fig. 1 is about 52% and the aperture of the pixel in the display of the invention shown in Fig. 2 is about 48%

25 Another advantage of the LCD 24 of the invention is that it can be easily made without causing changes in the capacitance of the capacitor between the select lines and the pixel areas. The various areas forming the pixel areas, select lines and data lines are formed by depositing a layer of the suitable material on the base plate and defining the layer using standard  
30 photolithographic techniques and etching to define the layer into the areas, strips and the like. The photolithographic techniques use a mask to define the position of the areas and strips. If the mask is not aligned perfectly, the position of the areas and strips may change. Thus, if the masks used to form either the pixel areas and/or the select lines, including the extensions, are not  
35 exactly aligned, the overlap between the extensions of the select lines and the pixel areas may vary. However, if the overlap between the extension at one side of the pixel area is changed, such as being made smaller, the overlap between the extension at the other side of the pixel area will also change in the

opposite manner, such as being made larger. Thus, the changes will balance each other so that the total overlap, and thus the capacitance, will remain the same. Therefore, slight misalignment of the masks used to form the pixel areas and/or the select lines will not cause a variation in the capacitance between the select lines and the pixel areas.

Referring now to Fig. 4, another form of the LCD of the invention is generally designated as 46. Display 46 includes a base plate 48 of an insulating material, such as glass, having on a surface 50 thereof a plurality of areas 52 of a conductive material, such as polycrystalline silicon. The conductive areas 52 form portions of the pixels and are arranged in a plurality of spaced rows and columns. Each of the conductive areas 52 is substantially in the form of a U having a top portion 53, and a pair of spaced, parallel leg portions 55 extending from the top portion 53. A contact extension 57 extends from each top portion 53 between the leg portions 55. A separate select line 54 of a conductive material, such as polycrystalline silicon, extends across the top portion 53 of each of the conductive areas 52 in a separate row. As shown in Fig. 5, the select line 54 is insulated from the conductive areas 52 by a layer 56 of a dielectric material, such as silicon oxide, preferably silicon dioxide, or silicon nitride. The select lines 54 have extensions 58 which extend over and along each leg portion 55 of each of the conductive areas 52. The extensions 58 are also insulated from the conductive areas 52 by the dielectric layer 56. Thus, the select line 54 and its extensions 58 form a capacitor with the conductive area 52.

A contact strip 60 of a conductive material, such as a metal, extends across the top portion 53 of each conductive area 52 and over the contact extension 57. As shown in Fig. 5, the contact strip 60 is insulated from the select line 54 by a layer 62 of an insulating material, such as silicon oxide, preferably silicon dioxide. The contact strip 60 extends through openings 64 and 65 in the dielectric layer 56 and the insulating layer 62 to make electrical contact with the contact extension 57. An area 66 of a conductive material, such as indium tin oxide (ITO) extends over a portion of each of the conductive areas 52 and the area within the U-shaped conductive areas 52. The ITO areas 66, like the conductive areas 52 are arranged in an array of spaced rows and columns and form the active portions of the pixels of the display 46. As shown in Fig. 5, the ITO areas 66 are insulated from the contact strips 60 by a layer 68 of an insulating material, such as silicon oxide, preferably silicon dioxide. Each ITO area 66 extends through an opening 70 in the insulating layer 68 and makes electrical contact with its respective contact strip 60.

Thus, each of the ITO pixel areas 66 is electrically connected to a conductive area 52 through a contact strip 60.

Data lines 72 of a conductive material, such as a metal, extend along the sides of the pixel areas 66 between the columns of the pixel areas 66. Each data line 72 is electrically connected to each of the polycrystalline silicon areas 52 in an adjacent column through a separate MOS transistor 74. Each MOS transistor 74 is formed by a strip 76 of polycrystalline silicon extending from a separate one of the polycrystalline silicon areas 52. A select line 54 extends across each of the strips 76 and is insulated therefrom by the insulating layer 56 to form the gate of the MOS transistor 74. The portions of the strip 76 on each side of the select line 54 form the source and drain of the MOS transistor 74. The data line 72 is insulated from the strips 76 and the select lines 54 by the insulating layers 56 and 62. The data line 72 extends through an opening 78 in the insulating layers 56 and 62 to make electrical contact with the strip 76 on the side of the select line 54 away from the polycrystalline silicon area 52 to which the strip 76 is connected.

Each ITO area 66 extends directly up to and may slightly overlap the data lines 72 at each side of each ITO area 66. Each ITO area 66 also overlaps its respective select line 54. By having the ITO areas 66 extending up to and/or overlapping the data lines 72 and the select lines 53, the ITO areas 66 electrically shield the liquid crystal material of the LCD 46 from fields generated by the data lines 72 and the select lines 52. Such electrical shielding minimizes disclination formation leading to improved contrast ratio in small pixels. A layer of a black matrix material may be coated over the select lines 54, data lines 72 and polycrystalline silicon areas 52 leaving at least a portion of each ITO area 66 exposed. The black matrix layer may exist as a single layer having openings therethrough over the ITO areas 66, or as strips extending over the data lines 72 and the selection lines 54 and the polycrystalline silicon areas 52. In the display 46, the portions of the select lines 54 which extend over and across the polycrystalline silicon areas 52 and the extensions 58 form capacitors with the polycrystalline silicon areas 52. The display 46 has a capacitance of over three times that of the capacitance of a display, such as shown in Fig. 1, where the select lines 54 do not have the extensions. Although the capacitance is greatly increased, the active area of the display is not substantially decreased with the aperture of the display 46 being about 51% and the aperture of the display 10 shown in Fig. 1 being 52% for the same size of pixel.



In Figs. 6 and 7, there is shown a top plan view and sectional view respectively of a modification of the LCD 46 shown in Fig. 4. In the LCD 46 of Fig. 4, the ITO areas 66 extend directly up to or slightly overlap the data lines 72 so as to shield the liquid crystal material from stray fields. However, this also creates strong capacitive coupling between the data lines 72 and the ITO areas 66. To eliminate this capacitive coupling, a metal shielding layer 80 is placed over the data lines 72 and under adjacent portions of the ITO areas 66 as shown in Fig. 6. The shielding layer 80 is insulated from the data lines 72 by a layer 82 of an insulating layer, such as silicon oxide and preferably silicon dioxide, as shown in Fig. 7. The shielding layer 80 is insulated from the ITO areas 66 by a layer 84 of an insulating material, such as silicon oxide and preferably silicon dioxide, as shown in Fig. 7. The shielding layer 80 not only prevents capacitive coupling between the select lines 72 and the ITO areas 66, but also serves as a black matrix layer. Thus, no additional black matrix layer is required.

Thus, there is provided by the invention a LCD in which the capacitance of the capacitor connected to each pixel is substantially increased to provide for greater stability of the display. Even though the capacitance is increased, the active area of the display is not substantially decreased since the increase in the capacitance is achieved using the wasted regions of the display between the columns of the pixels. Furthermore, the increase in capacitance is achieved without increasing the number of steps necessary to make the display since the extensions to the select lines are formed during the same step that the polycrystalline silicon layer which forms the select lines is defined.

What is claimed is:

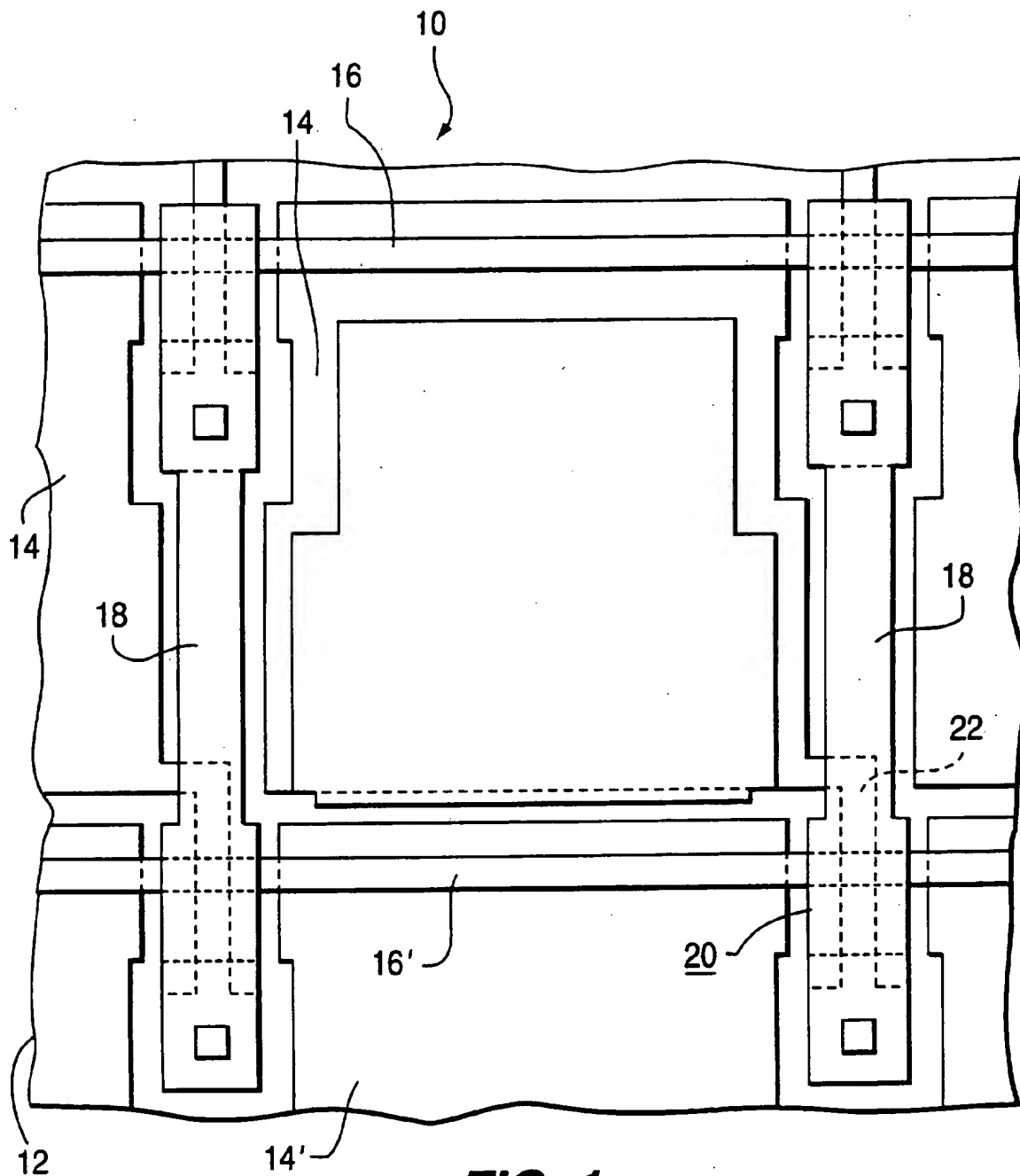
1. A liquid crystal display comprising:  
a base plate having a surface;  
at least one pixel on said surface of the base plate, said pixel including at  
5 region of a conductive material having a plurality of sides;  
a conductive first line extending over and across said region adjacent  
one side thereof;  
at least one conductive extension extending from the first line over and  
across another side of the region; and  
1 0 a layer of a dielectric material between the region and the first line and  
its extension;  
said first line and extension forming with the region a capacitor which is  
electrically connected to said region.
2. The display of claim 1 wherein the first line has two conductive  
1 5 extensions extending therefrom over and along different sides of the region, and  
the dielectric layer is between the line and both extensions and the region.
3. The display of claim 2 including a second line of a conductive material  
extending along a side of the region and electrically connected to the region.
4. The display of claim 3 in which the second line extends along the same  
2 0 side of the region as one of the extensions of the first line.
5. The display of claim 4 including a MOS transistor connected between  
the second line and the region.
6. The display of claim 5 in which the region, the first line and the  
extensions of the first line are of polycrystalline silicon.
- 2 5 7. The display of claim 6 in which the conductive region is substantially  
rectangular, the first line extends over and along the region adjacent one side of  
the region, the extensions of the first line extend from the first line over and  
along the region adjacent two opposite sides of the region, and the portion of  
the region between the first line and the extension is the active areas of the  
3 0 pixel.
8. The display of claim 6 comprising:  
a substantially rectangular area of indium, tin oxide over and insulated  
from the polycrystalline silicon region and electrically connected to the  
polycrystalline silicon region, said indium, tin oxide area forming the active  
3 5 region of the pixel; and wherein:  
the indium, tin oxide area extends at least directly up to each of the first  
and second lines; and further comprising a metal shielding layer over the  
second line and under an adjacent portion of the indium, tin oxide area, said

shielding layer being electrically insulated from the second line and the indium, tin oxide area.

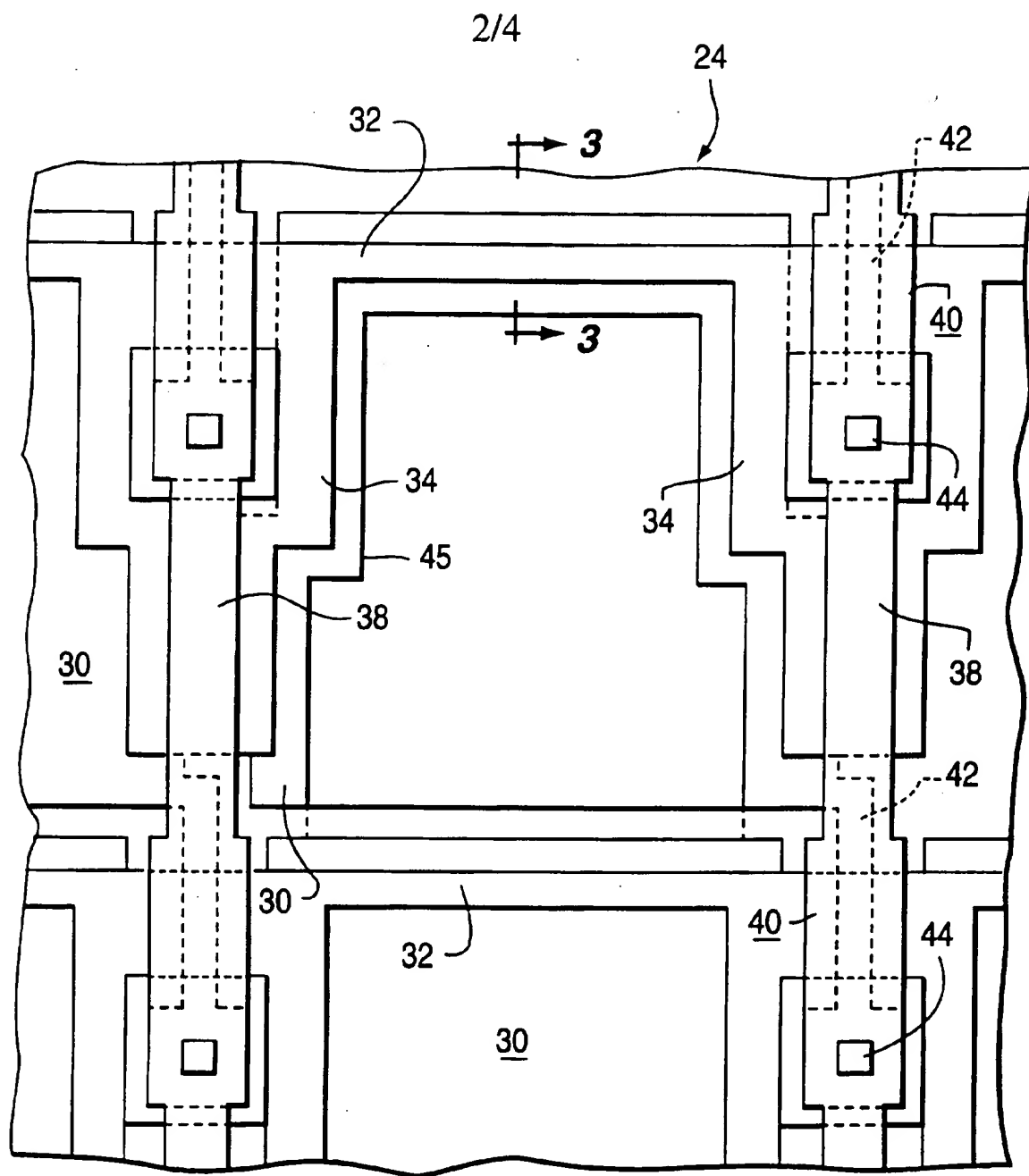
9. The display of claim 1 comprising:

- 5 a plurality of pixels on said surface of the base plate and arranged in an array of spaced rows and columns, each of said pixels including a region of a conductive material having a plurality of sides.

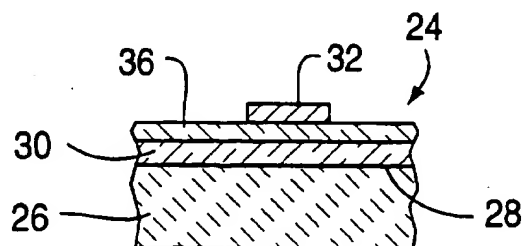
1/4



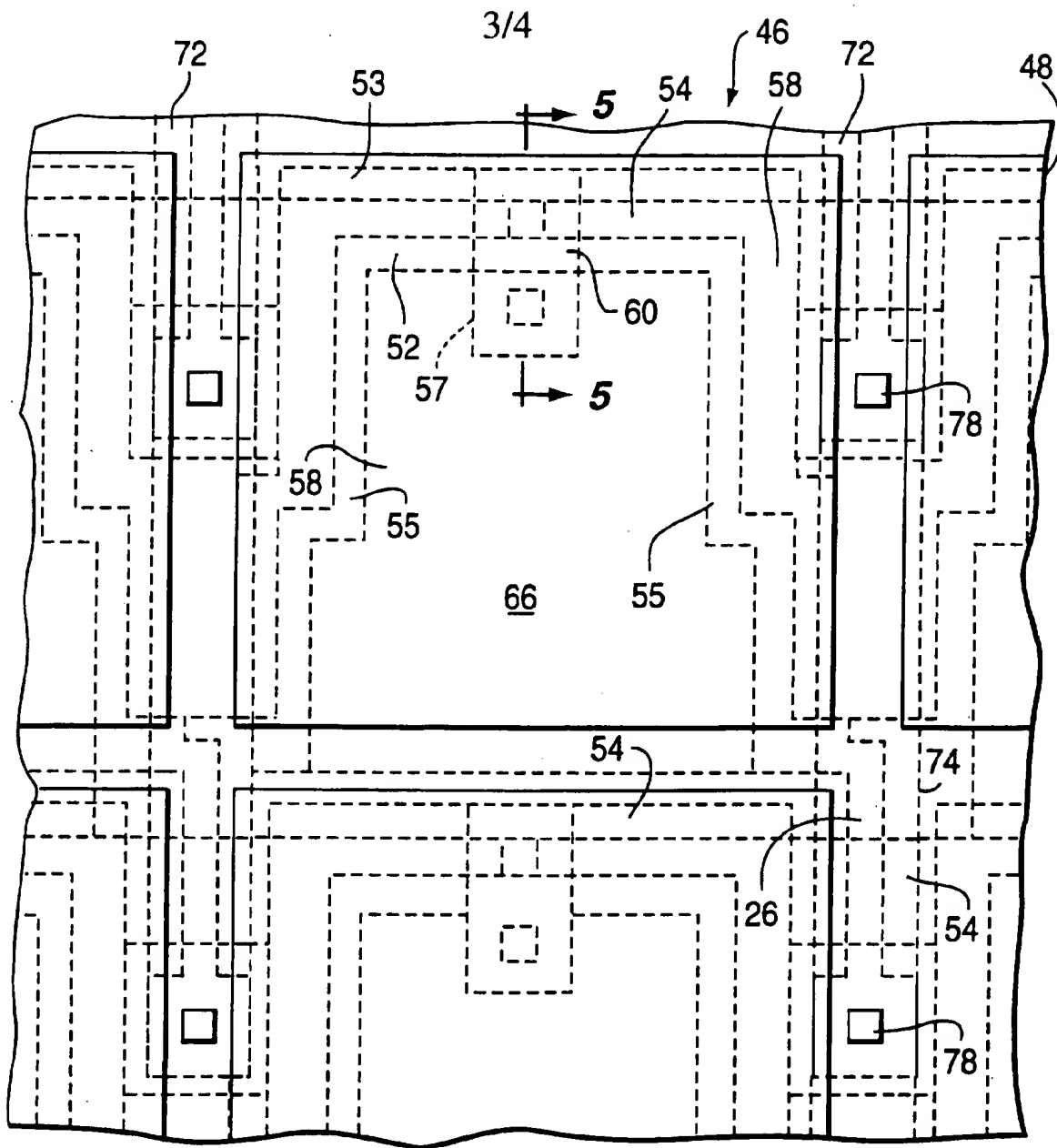
**FIG. 1**  
**PRIOR ART**



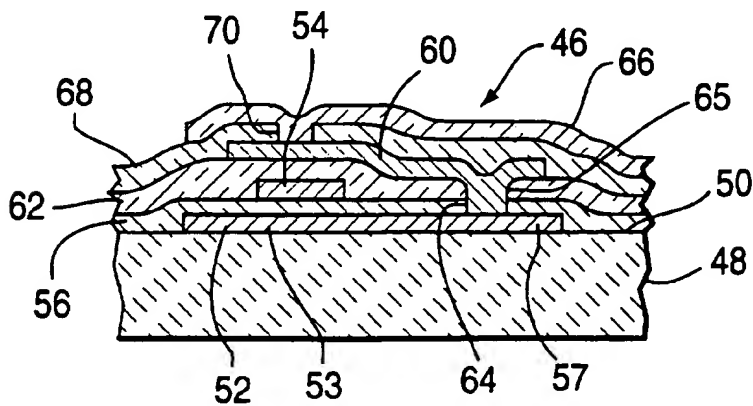
**FIG. 2**



**FIG. 3**

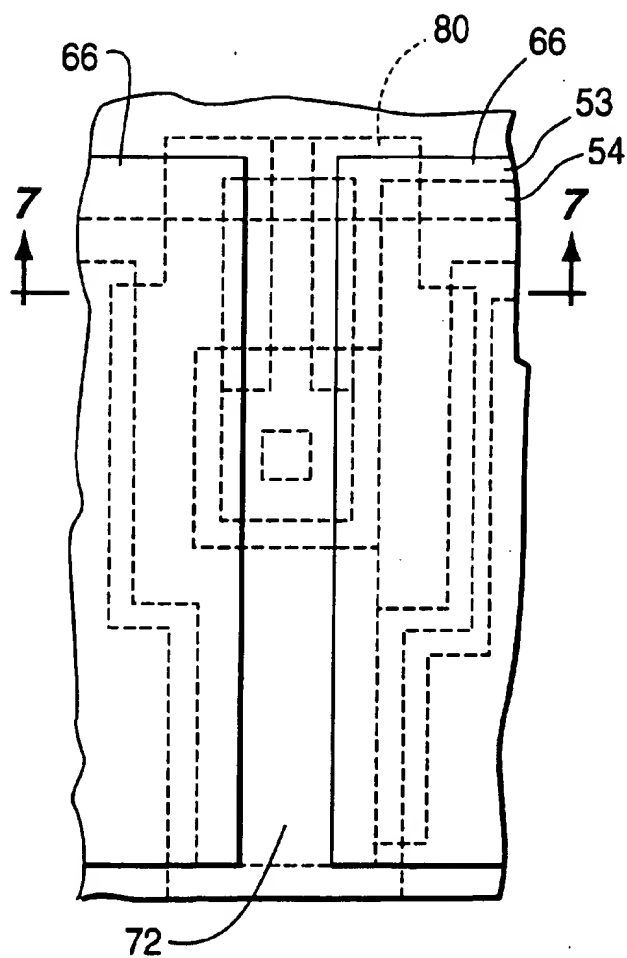


**FIG. 4**

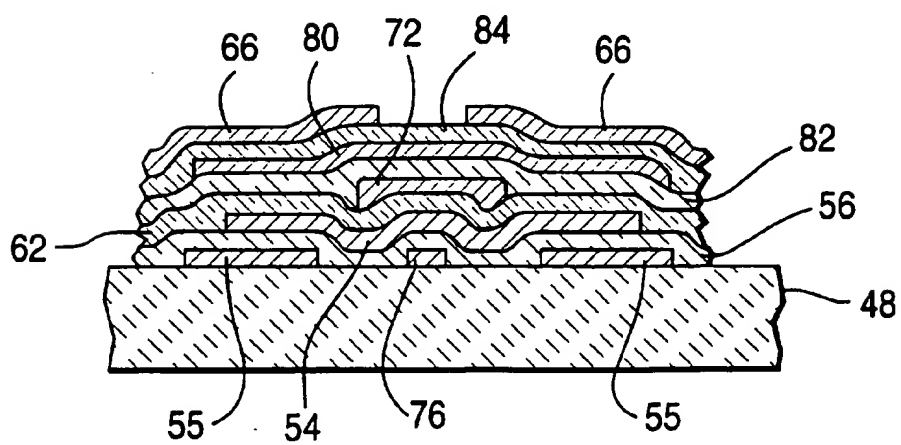


**FIG. 5**

4/4



**FIG. 6**



**FIG. 7**

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US95/08785

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) : G02F 1/1343

US CL : 359/59, 87

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 359/59, 87

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

search terms: gate line, select line, extension, capacitance, capacitor, liquid crystal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ----- Y	JP, A, 4-264529 (TANIGUCHI ET AL) 21 September 1992, abstract and figure 9.	1-5, 9 ----- 6-8
Y	US, A, 5,159,477 (SHIMADA ET AL) 27 October 1992, col. 2, line 43, through col. 3, line 11.	6-8
A	US, A, 5,055,899 (WAKAI ET AL) 08 October 1991, see figure 3.	1-9
A	US, A, 5,054,887 (KATO ET AL) 08 October 1991, see entire document.	1-9
A	US, A, 4,968,119 (STEWART) 06 November 1990, see the entire document.	1-9



Further documents are listed in the continuation of Box C.



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